Table A1

Values of the Standard Errors of Regression

Data to 1992

DX	Christensen Data Equation (4)	Christensen Data Equation (5)	NERA Data Equation (4)	NERA Data Equation (5)
D85	3.927	3.973	3.503	3.465
D86	3.816	3.901	3.383	3.374
D87	3.777	3.887	3.358	3.368
D88	3.748	3.891	3.342	3.381
D89	3.458	3.676	2.977	3.105
D90	3.064	3.400	2.428	2.730
D91	3.519	3.758	3.106	3.242
D92	3.437	3.740	3.021	3.236

Table A2

Values of the Standard Errors of Regression

Data to 1993

DX	Christensen Data Equation (4)	Christensen Data Equation (5)	NERA Data Equation (4)	NERA Data Equation (5)
D85	3.935	3.963	3.488	3.422
D86	3.835	3.895	3.382	3.333
D87	3.804	3.883	3.366	3.329
D88	3.782	3.888	3.360	3.343
D89	3.518	3.685	3.036	3.078
D90	3.165	3.425	2.563	2.719
D91	3.585	3.767	3.169	3.213
D92	3.520	3.751	3.114	3.209
D93	3.548	3.762	3.168	3.238

Table A.3

Testing the Two Competing Hypotheses Using the J Test

Data to 1992

Data Set and Equation Nos.	Hypothesis	t - Statistic for α	Critical 5% Value of t	P-Value
Christensen Eqs (2)&(4)	H1 versus HC	3.37	1.96	.0008
	H2 versus HC	0.57	1.96	.5693
Christensen Eqs (3)&(5)	H1 versus HC	2.94	1.96	.0033
	H2 versus HC	-0.09	-1.96	.9247
NERA Eqs (2)&(4)	H1 versus HC	4.14	1.96	.0000
	H2 versus HC	0.13	1.96	.8978
NERA Eqs (3)&(5)	H1 versus HC	3.63	1.96	.0003
	H2 versus HC	-0.70	-1.96	.4859

Table A.4

Testing the Two Competing Hypotheses Using the J Test

Data to 1993

Data Set and Equation Nos.	Hypothesis	t - Statistic for α	Critical 5% Value of t	P-Value
Christensen Eqs (2)&(4)	H1 versus HC	3.01	1.96	.0026
	H2 versus HC	1.37	1.96	.1705
Christensen Eqs (3)&(5)	H1 versus HC	2.70	1.96	.0069
	H2 versus HC	0.52	1.96	.6016
NERA Eqs (2)&(4)	H1 versus HC	3.59	1.96	.0003
	H2 versus HC	0.96	1.96	.3391
NERA Eqs (3)&(5)	H1 versus HC	3.47	1.96	.0005
	H2 versus HC	-0.20	-1.96	.5789

Table A.5

Testing the Two Competing Hypotheses Using the Cox Test

Data to 1992

Data Set and Equation Nos.	Hypothesis	Standard Normal Statistic (N) for α	Critical 5% Value of N	P-Value
Christensen Eqs (2)&(4)	H1 is correct	-6.00	-1.96	.0000
	H2 is correct	-0.58	-1.96	.5640
Christensen Eqs (3) &(5)	H1 is correct	-5.08	-1.96	.0000
	H2 is correct	0.09	1.96	.9294
NERA Eqs (2)&(4)	H1 is correct	-9.31	-1.96	.0000
	H2 is correct	-0.11	-1.96	.9109
NERA Eqs (3)&(5)	H1 is correct	-7.42	-1.96	.0000
	H2 is correct	0.55	1.96	.5800

Table A.6

Testing the Two Competing Hypotheses Using the Cox Test

Data to 1993

Data Set and Equation Nos.	Hypothesis	Standard Normal (N) Statistic for α	Critical 5% Value of N	P-Value
Christensen Eqs (2)&(4)	H1 is correct	-5.17	-1.96	.0000
	H2 is correct	-1.63	-1.96	.1026
Christensen Eqs (3)&(5)	H1 is correct	-4.66	-1.96	.0000
	H2 is correct	-0.55	-1.96	.5819
NERA Eqs (2)&(4)	H1 is correct	-7.61	-1.96	.0000
	H2 is correct	-1.02	-1.96	.3097
NERA Eqs (3)&(5)	H1 is correct	-7.40	-1.96	.0000
	H2 is correct	0.17	1.96	.8616

December 1995

CURRICULUM VITAE

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PERSONAL BACKGROUND

Date of Birth: March 29, 1940
Marital Status: Married, one child
Citizenship: Canadian

EDUCATION

Ph.D University of California (Berkeley), 1970 (Economics)
M.A University of Toronto, 1965 (Economics)
B.Sc. University of Toronto, 1963 (Mathematics and Physics)

HONOURS AND AWARDS

Province of Ontario Fellowship, 1964-65
University of California Fellowship, 1965-66
Canada Council Predoctoral Fellowships, 1966-69
American Telephone and Telegraph Post - Doctoral Fellowship in Public Utility Economics, 1971-72
Canada Council Leave Fellowship, 1978-79
Canadian Studies Visiting Professorship, Hebrew University of Jerusalem, 1987-88

PROFESSIONAL EXPERIENCE

Rank/Position	Department	Institution	Dates
Instructor	Economics	Harvard University	1969-70
Assistant Professor	Economics	Harvard University	1970-72
Associate Professor	Economics	University of Toronto	1972-79
Professor	Economics	University of Toronto	1979-present
Associate Chairman	Economics	University of Toronto	1984-85
Chairman	Economics	University of Toronto	1985-90
Research Associate	Institute for Policy Analysis	University of Toronto	1972-present
Research Associate		National Bureau of Economic Research	1983-present
Visiting Professor	Economics	Hebrew University of Jerusalem	1973
Visiting Scholar	Economics	University of California, Berkeley	1975
Visiting Scholar	Economics	Stanford University	1975-76
Visiting Professor	Economics	Hebrew University of Jerusalem	1987-88
Visiting Scholar	Research	Bank of Israel	1987-88
Editor		Journal of Productivity Analysis	1992-present

TEACHING EXPERIENCE

(i) Harvard University

Undergraduate
- principles
- economics of regulation

Graduate
- industrial organization
- introductory econometrics
- advanced econometrics
- microeconomic theory

(ii) Hebrew University of Jerusalem

Graduate
- seminar in production theory
- econometrics

(iii) University of Toronto

Undergraduate
- advanced microeconomic theory
- industrial organization
- econometrics
- economics of regulation

Graduate
- microeconomics theory
- econometrics

CONSULTING EXPERIENCE

consultant to:

Abt Associates
Association of Canadian Distillers
Canada-U.S. Select Panel on the State of the North American Auto Industry
Canadian Cable Television Association
Chrysler Corporation
Data Resources Inc.
Edmonton Telephones
Electric Power Research Institute
Federal Department of Communications
Federal Department of Finance
Federal Department of Energy, Mines and Resources
Gulf Canada Ltd.
Ontario Hydro
Ontario Legislature
Ontario Ministry of Energy
Ontario Ministry of Transportation and Communications
Ontario Ministry of Industry, Trade and Technology
Sierra Club of Ontario
Southern New England Telephone Company
Statistics Canada
Teleglobe Canada
United States Postal Service
United States Postal Rate Commission
United States Department of Justice
Unitel / Canadian Pacific Telecommunications

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"A Survey of Functional Forms in the Economic Theory of Production" (with D. McFadden and Y.Mundlak), Chapter II.1 in M. Fuss and D. McFadden (ed.) Production Economics: A Dual Approach to Theory and Applications, North-Holland, 1978, Vol. 1, pp. 219-268.

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"Cost Allocation: How Can the Costs of Postal Services be Determined?", Chapter 3 in H. Sherman (ed.) Perspectives on Postal Service Issues, American Enterprise Institute for Public Policy Research, Washington, D.C., 1980, pp. 30-46.

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"Canadian Energy Demand and Supply" (with L. Waverman) in "Energy Demand, Prices and Investment", PEAP Policy Paper No. 7, Institute for Policy Analysis, University of Toronto, December 1978, pp. 27-46.

"Modelling the Cost and Production Structures of Manufacturing Industries", Economic Policy Review, Institute for Policy Analysis, University of Toronto, vol II, 1980, pp. 17-42.

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7

Bell Atlantic

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Joseph J. Mulieri
Director – FCC Relations

June 28, 1996

James D. Schlichting, Chief
Competitive Pricing Division
Federal Communications Commission
Room 518
1919 M Street, N.W.
Washington, D.C. 20554

Dear Jim:

The attached Report of Bell Atlantic provides the material you requested relating to the impact of increased Internet usage on Bell Atlantic's network. As shown in the Report, Bell Atlantic surveyed representative central offices in the Washington, D.C. metropolitan area in which Internet Service Providers receive significant amounts of terminating traffic. The results are summarized in the Report and accompanying charts.

The cost impact figures that appear in the Report are close approximations, but they demonstrate the type of cross-subsidies that increased Internet use is causing, and can expected to cause in the future. Bell Atlantic will continue to refine its studies to provide additional data in the course of any future proceeding.

Please do not hesitate to contact me with any questions or for additional information.

Sincerely,

Joseph Mulieri (rm)

Attachment

REPORT OF BELL ATLANTIC ON INTERNET TRAFFIC

Bell Atlantic submits data today to assist the Commission staff in the evaluation of current arrangements which are available to Internet Service Providers (ISPs) to obtain access to their customers. Through the Enhanced Service Provider (ESP) exemption, ISPs are permitted to obtain their access services from local service tariffs. Local services are provided via network technology which was designed in anticipation of far different traffic characteristics than are currently being experienced. Bell Atlantic, through submission of these data, encourages the Commission to consider elimination of or modifications to the ESP exemption.

This submission is organized into five sections. The first section describes how the ISPs purchase services from Bell Atlantic today, including general information on prices for these services. The second section describes a traffic study which Bell Atlantic conducted on seven ISPs in the Virginia, Maryland and Washington, D.C area. The third section describes how ISP traffic loads have affected the network. The fourth section describes cost impacts. The final section describes suggestions as to how the FCC may address the issues raised by the ESP exemption, including a discussion on how correct economic pricing may provide better incentives for the ISPs to subscribe to services based technologies which can more efficiently handle ISP traffic patterns.

At the outset, Bell Atlantic views the recent development of the Internet, including use of the World Wide Web, as very positive for society and the telecommunications industry. While changes are needed to address problems caused by current access arrangements, we are committed to finding solutions which will sustain continued growth and interest in use of the Internet by the public at large. In fact, the changes Bell Atlantic is seeking to define, should help sustain growth by providing incentives for ISPs to embrace more efficient emerging technologies by eliminating artificial pricing arrangements that discourage use of improved technology. At the same time, Internet growth should not occur in ways that require cross-subsidization by non users of the Internet, or worse, lead to potential disruption of vital public safety services such as 911 emergency call service.

SECTION ONE - Current ISP Access Arrangements

ISPs currently use several interconnection arrangements purchased from local service tariffs to transport calls from their subscribers to their centrally located network aggregation centers. These network centers typically house modems, routers, WWW servers, authentication servers, mail servers, etc. Traffic collected at these network centers is routed to the Internet backbone over dedicated facilities, or to other on-line services. Placement of these centers often is a function of minimizing local access costs, i.e. maximizing the number of subscribers that can be reached on a flat rate, local call, untimed basis.

DDD Network Dial In Analog Access - Attachment 1

The most common interconnection arrangement is to use the existing DDD network to provide dial-in access to an analog "modem pool" for those customers who can reach the hub central office on a local call basis. The ISP's subscribers dial in to the lead number of the multiline hunt group serving the ISP, and the DDD network makes the connection. Depending upon the size of the multiline hunt group, and the features and functionality desired, many ISPs decide to purchase either Business Dial Tone Line, Engineered CENTREX or CustoFLEX 2100 from the hub central office.

The price for Business Dial Tone Line service in Virginia, for example (including Subscriber Line Charge), varies from a low of $16.93 to a high of $18.93 per month, per line. There are no usage charges to the ISP since all traffic is incoming from the ISP's subscribers, and local tariffs contain no charges for terminating usage.

Primary Rate ISDN Access - Attachment 2

In order to obtain additional functionality and higher transport speeds, and to reduce their costs of operation, many ISPs are beginning to purchase ISDN PRI (Primary Rate Interface) service. Each PRI facility is equipped to handle 24 circuits (in most cases one circuit is required for signaling). The price of an ISDN PRI facility in Virginia (including Subscriber Line Charge) is

$455.93 per month. Again, there are no usage charges billed to the ISP since all traffic is incoming from the ISPs subscribers.

SECTION TWO - Traffic Study

While field operations personnel report on a firsthand basis the effects of heavy traffic patterns associated with access into ISP facilities (see SECTION THREE below), we concluded that a more systematic approach to measuring traffic loads was needed to substantiate impact on our network. ISPs submit orders for local services (see SECTION ONE above) through our business offices in similar fashion to any other end user business customer, therefore their facilities cannot be separately identified for collection of usage data. Orders flow through our provisioning systems on a mechanized basis, and are not screened to enable identification of ISP facilities as such.

Thus the first step for the study was to ask the sales account teams in our Large Business Sales organization (the sales unit that has responsibility for the larger ISPs) to randomly select a number of ISPs who were known to have ordered service in the Virginia, Maryland, Washington, D.C. area. We selected these three jurisdictions due to the ready availability of trained personnel who had the knowledge of how to perform a usage study of the type required.

Even though calls from end users (for example, people dialing up over modems from their homes) increase traffic loads on the central offices that serve the end user, the heaviest concentration of traffic loads are occurring in the central offices that serve the ISPs. These central offices are where the earliest impacts on network resources are being observed. Therefore we selected lines from the ISPs that terminate into their serving central offices as the point at which to perform our traffic study.

We determined that by measuring traffic continuously over a 24 hour period for 7 days a week, for a period of four weeks we could obtain a meaningful sample of the overall impact within the region. Given that our computer systems were collecting information for each call made during this sample period, the quantity of data to be collected was quite large. Thus we determined that we did not want to exceed ten central offices and 5000 total circuits for this study, in order to manage the quantity of data that would be collected. The final study design resulted in selection of 7 ISPs in 9 central offices (5 in VA, 2 in MD and 2 in Washington, D.C.) and 4887 circuits. New circuits within a multiline hunt group ordered by each of the ISPs during the four week sample period were automatically added to the sample.

We selected a four week period (February 25 - March 23) to avoid holidays and other "events" that might lead to traffic spikes. Of the 4887 ISP circuits that we sampled, approximately half involved PRI connections, and the other half involved standard analog connections. The central offices selected varied in their mix of residential and business customers.

In addition to sampling ISP circuits, we also determined that it would be useful to have a benchmark traffic sample with which to compare results. Within the same 9 central offices, and during the same 4 week period, we selected 16 business/government customers having multline hunt groups serving multiple lines. We sampled a total of 777 lines for these 16 customers. As another benchmark, we also collected total usage for the 9 central offices during the 4 week sample period.

The output of the study was number of "hundred call seconds" (CCS) on an hourly basis. (There are 3600 seconds per hour, or 36 CCS if the line is used continuously during the hour). Our measuring system determined the time for each completed call per line, accumulated that usage on an hourly basis and converted the results into hourly CCS. For the peak hour of each segment studied, averaged over the four week period, the CCS results were as follows:

SAMPLE SEGMENT	AVERAGE PEAK HOUR CCS*	PEAK HOUR FOR SEGMENT
ISPs on 1MB (measured business)	26 CCS	11:00 PM
ISPs on PRI (primary rate interface)	28 CCS	10:00 PM
Business Customers with MLHG	12 CCS	5:00 PM
Office average (entire central office)	3 CCS	4:00 PM

* Maximum utilization is 36 CCS per hour

In order to provide a more visual display of results from the study, we selected Wednesday, March 13, and plotted the hourly CCS results for the four segments in each of the 9 central offices studied. The graphs are attached to this report. Names of both the customers and the central offices are masked to protect the privacy of our customers.

Another key output from the study was average length of completed calls. For the four week study period, the average length of all ISP calls was 17.7 minutes. This compares to approximately 4 to 5 minutes as the average for all other calls on our network.

The results of the study clearly demonstrate traffic levels for ISPs which are significantly above normal customer traffic levels. The results of our study also showed that the heavy traffic levels shown in the above table were consistent throughout the study period (See "Composite Graph For All 28 Days" attached), adding to our ability to conclude that this study provides a fair representation of the traffic levels which are occurring on our network attributable to ISP usage.

SECTION THREE - Network Impacts

In this section, we will describe the impact ISP traffic is having on our network.

Traffic engineers size switches based on an average usage assumption of about nine minutes per line during the peak hour (5CCS). Individual business customers may normally be in the range of 7 - 8 CCS. As our study demonstrated, traffic levels from ISPs greatly exceed this level, and approach 30 CCS in their peak hour. At the traffic levels they are generating, we estimate that the overall traffic loads on the local network would double if only a 15% penetration of households were connected to the Internet. Stated another way, if just 15% of households went on line to the Internet at one time and had a call hold time of one hour, it would double the capacity demanded. The reason is that 15% of households on line for an hour has the same effect as 100% of households making a nine minute call in that same hour (5CCS). With on-line data services, a relatively small user group can stress the network in ways which have not previously occurred, and were not contemplated in designing the network.

Heavy traffic loads affect certain elements of the network, the primary elements being Line Units (LU), Switch Modules (SM), and interoffice facilities (IOF). Subscriber lines terminate into LU's when analog services are ordered (e.g. 1MB). Under normal circumstances (i.e. traffic loads in the range of 3 - 5 CCS), each LU can accommodate approximately 450 subscriber lines, with a maximum capacity of 512 lines. As traffic loads on incoming lines increases, the number of lines which the LU can accommodate decreases. If all lines are at the 25 - 30 CCS level, then the LU can accommodate only about 65 subscriber lines. This would mean a 7-fold increase in the number of LUs needed to accommodate the same number of lines at an approximate cost of $60,000 per LU. Since there are 7 LUs per SM, investments in SMs will also increase. The need to add LUs and SMs exists even if ISP traffic peaks at a different time than the central office as a whole, because this equipment is dedicated to individual lines and cannot accept overflow traffic.

Interoffice facilities (IOF) requirements are also engineered to meet peak requirements. The peak busy hour for IOF trunks will vary throughout the network, and is influenced by community of interest factors associated with customers served by the central offices. The emergence of